

Antenna for flat radio device

The invention relates to an antenna intended to be used in a small-sized and flat radio device. The invention also relates to a radio device which has an antenna according to the invention.

5 BACKGROUND OF THE INVENTION

Commercial portable radio devices, such as mobile phones, include models with a total device depth of about one centimeter, for example. Such flat structures are especially the folding parts of flip-type mobile phones. A flip phone has got two parts such that the parts can be folded over, on a hinge, so that they lie on top of each other or adjacently end-to-end in almost the same plane. In the first position, the device is particularly small, and it is in the latter position during connection.

Antennas used in flip phones are normally monopole-type external antennas. Their drawback is the inconvenience generally associated with a protruding structural element. Naturally it would be possible to use internal PIFA-type planar antennas,

15 but the thin structure of the folding parts in the mobile phone would result in the distance between the radiating part and ground plane to be so small that the antenna gain would be unsatisfactory. Furthermore, it would be possible to have an internal monopole-type planar antenna such that the radiating plane does not face the ground plane. In that case the flatness of the device would cause no problem as such, but 20 the electrical characteristics such as matching and antenna gain would again be unsatisfactory. Matching could be improved using an additional circuit, but this would require the use of several discrete components.

SUMMARY OF THE INVENTION

It is an object of the invention to eliminate the aforementioned drawbacks associated with the prior art. An antenna according to the invention is characterized in that 25 which is specified in the independent claim 1. A radio device according to the invention is characterized in that which is specified in the independent claim 10. Some advantageous embodiments of the invention are specified in the other claims.

The idea of the invention is basically as follows: Base element of the antenna of a 30 flat radio device is an internal monopole-type conductor. This conductor may be designed such that the harmonic nearest the fundamental resonating frequency can be utilized for providing an upper operating band. In addition to the base element

the antenna structure includes a parasitic element which serves as both auxiliary radiator and antenna matching element. Matching is optimized by an inductive structure part which connects the parasitic element to signal ground.

One of the advantages of the invention is that it yields an antenna gain significantly
5 higher than known antenna structures occupying the same space. Another advantage
of the invention is that the antenna gain is better compared to known internal
monopole antennas. Still another advantage of the invention is that the parasitic
element according to the invention can be further used for widening at least one
10 operating band by appropriately offsetting its resonating frequency from the
corresponding resonating frequency of the base element. Still another advantage of
the invention is that the arrangement according to the invention is simple and incurs
relatively little production costs.

BRIEF DESCRIPTION OF THE DRAWINGS

The invention will now be described in detail. Reference is made to the accompa-
15 nying drawings in which

- Fig. 1 shows an example of an antenna according to the invention,
- Fig. 2a shows a second example of an antenna according to the invention,
- Fig. 2b shows a side view of the antenna of Fig. 2a,
- Fig. 3a shows a third example of an antenna according to the invention,
- 20 Fig. 3b shows a side view of the antenna of Fig. 3a,
- Figs. 4a,b show an example of a radio device equipped with an antenna according
to the invention,
- Fig. 5 shows an example of the matching of an antenna according to the inven-
tion, and
- 25 Fig. 6 shows an example of the efficiency of an antenna according to the
invention.

DETAILED DESCRIPTION OF THE INVENTION

Fig. 1 shows a first example of an antenna according to the invention. Shown is a
radio device circuit board 101 to one end of which an antenna is connected. The
30 main components of the antenna are a base element 110 and parasitic element 120.
In this example the base element is a rigid conductive wire resembling an open rec-

tangular ring. In a corner of the base element 110, situating on the circuit board 101 side, there is a feed point **F** which is connected to the antenna port of the radio device through a feed conductor 105. The antenna port and the transmitter and receiver of the radio device are located on the opposite side of the circuit board 101
5 and are not visible in Fig. 1. The upper surface of the circuit board is mostly conductive signal ground GND. This, however, does not extend to the antenna, so the base element 110 together with the feed conductor 105 constitute a monopole-type radiator. In this example the monopole radiator has got two bands. Its fundamental resonating frequency falls into a frequency range used by a first radio
10 system, and the harmonic nearest the fundamental resonating frequency falls into a frequency range used by a second radio system. For achieving an appropriate ratio between the harmonic and the fundamental resonating frequency the base element 110 has got two branches: It is divided into a first branch B11 and a second, shorter, branch B12, as viewed from the feed point **F**. There is an electromagnetic coupling
15 between the outer ends thereof, which decreases said ratio between the harmonic and the fundamental resonating frequency.

The parasitic element 120, too, is in this example a rigid conductive wire and it is located below the base element, approximately in the plane of the circuit board 101. The parasitic element is connected at its point **G** to signal ground GND through an
20 inductive element 125. The latter is a conductive wire making one turn, approximately. Point **G** divides the parasitic element into two parts B21, B22. The first part B21 together with the inductive element resonates in the lower operating band of the antenna, i.e. in the frequency range used by the first radio system. The second part B22 together with the inductive element resonates in the upper
25 operating band of the antenna, i.e. in the frequency range used by the second radio system. Oscillation energy naturally comes from the field of the base element through electromagnetic coupling. Thus, in this example, the parasitic element functions as an auxiliary radiator and enhances antenna gain in both operating bands of the antenna. The dimensions of the parts of the parasitic element and inductive
30 element 125 are chosen so as to achieve optimal matching for the whole antenna.

By a structure like the one described above the object of the invention, i.e. an antenna which fits into a flat radio device and yet has sufficiently good electrical characteristics, is achieved. This means that the height **h** of the antenna, i.e. the perpendicular distance of the basic element 110 from the radio device circuit board
35 101, can be reduced, as compared to an equally good PIFA, for instance.

The parasitic element 120 can also be used to widen one or both of the operating bands. This is done in a manner, known as such, by making the base element resonating frequency and the parasitic element resonating frequency somewhat different. However, the frequency difference has to be limited such that

5 the matching of the antenna remains good enough over the whole range between the resonating frequencies.

Figs. 2a,b show a second example of an antenna according to the invention. In Fig. 2a the structure is shown from above, and in Fig. 2b from the side. The antenna, like that in Fig. 1, comprises a radio device circuit board 201, antenna base element 210, 10 parasitic element 220, and an inductive element 225 which connects the latter to signal ground. This structure differs from that of Fig. 1 in that both the parasitic element and inductive element are conductive strips on the circuit board 201. The inductive element 225 constitutes a spiral pattern and it is located on opposite side of the circuit board compared with the parasitic element 220.

15 Figs. 3a,b illustrate a third example of an antenna according to the invention. In Fig. 3a the structure is shown from above, and in Fig. 3b from the side. The antenna includes a radio device circuit board 301, antenna base element 310, parasitic element 320, and an inductive element 325 which connects the latter to signal ground. In this example the base element 310 is a conductive strip on the circuit 20 board 301. The base element is not branched like in Figs. 1 and 2. Instead, its far end 312 is right beside the portion 311 starting from the feed point F in order to produce a relatively strong electromagnetic coupling. This design produces an appropriate ratio between the fundamental resonating frequency and its nearest harmonic. The parasitic element 320 is now located above the base element, i.e. 25 elevated from the circuit board 301, and it is made of sheet metal by cutting. The inductive element 325 is a small coil of rigid wire, placed between an extension of the parasitic element and ground plane. Fig. 3b further shows a dielectric block 370 supporting the parasitic element on the circuit board.

Fig. 4 shows an example of a radio device according to the invention. The radio 30 device 400 is a flip-type mobile phone having a first part 402 and second part 403 which parts are beared by a hinge. These parts are considerably flatter than an ordinary mobile phone having a single covering. In Fig. 4a, the first and second parts make almost a straight angle between them, and in Fig. 4b they are turned face to face. An antenna 440 as described above is located within the first part 402. 35 Naturally it could be placed within the second part 403 as well.

- Fig. 5 shows an example of the matching of an antenna according to the invention. The example relates to the antenna depicted in Fig. 1 in a flip-type mobile phone. The height h of the antenna is 3.5 mm. The quality of the matching appears from the values of the reflection coefficient S_{11} . Curve 51 shows the variation of the reflection coefficient as a function of the frequency when the folding parts of the mobile phone are positioned face to face, and curve 52 shows the same variation when the mobile phone is open. The curves show that the lower one BD1 of the two operating bands of the antenna covers the frequency band of the GSM900 (global system of mobile communications), and the upper operating band BD2 covers those of the GSM1800 and GSM1900 systems, for example. The dimensions of the parasitic element are chosen such that especially the upper operating band is very wide. Opening the phone improves the matching especially in the lower operating band, at the same time shifting the latter down somewhat. Changes in the upper operating band are smaller.
- Fig. 6 shows an example of the efficiency of an antenna according to the invention. The efficiencies are measured in a similar structure as matching curves in Fig. 5. Curve 61 shows the variation of the efficiency in the lower and upper operating bands when the folding parts of the mobile phone are positioned face to face, and curve 62 shows the same variation when the mobile phone is open. Looking at the curves one can see that opening the phone improves the efficiency in both the lower and upper operating band from about 0.4 to about 0.5-0.55. Given as antenna gain, i.e. relative field strength measured in the most favorable direction, the readings correspond to values greater than one.
- When a flip-type phone is in the closed position, it suffices that signaling between it and a base station works. The results depicted in Figs. 5 and 6 show that an antenna according to the invention is acceptable in this respect.
- Some antenna structures according to the invention were described above. The invention does not limit the shapes and implementation of the antenna elements to those just described. The invention idea can be applied in different ways within the scope defined by the independent claim 1.